Interreg North-West Europe NWE-REGENERATIS

European Regional Development Fund

D. I1.1.2 Site Specific Investigation Plan and Schedule for Teesside site (UK)

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FIGURE AND TABLES

1 INTRODUCTION

1.1 TEESSIDE SITE OVERVIEW

The South Tees Development Corporation [STDC] site is a large site (1500 ha) with a 160-year history of iron and steel production and the processing of finished products. Approximately 224 ha of land is associated with ironmaking, and 14 ha is associated with the South Bank Coke Ovens. In addition, 26 ha is associated with the South Lackenby Effluent Management System (SLEMS). It comprises large areas of Redcar, Lackenby, Grangetown and South Bank to the South of the River Tees.

The site has been used, at varying periods, for the storage of feedstock, products, by-products, and waste streams. Over the years, due to changes in ownership, regulatory controls and economic conditions, the materials have co-mingled with poor associated recording of the inventories of quantity and quality of materials. The materials have also co-mingled with natural ground materials. This includes dispersal in soil, rock, clay, silt, and other materials arising from its tidal estuary location. The stratigraphy is, therefore, varied and complex. The Teesside PMSD site area is shown in Figures 1 and 2.

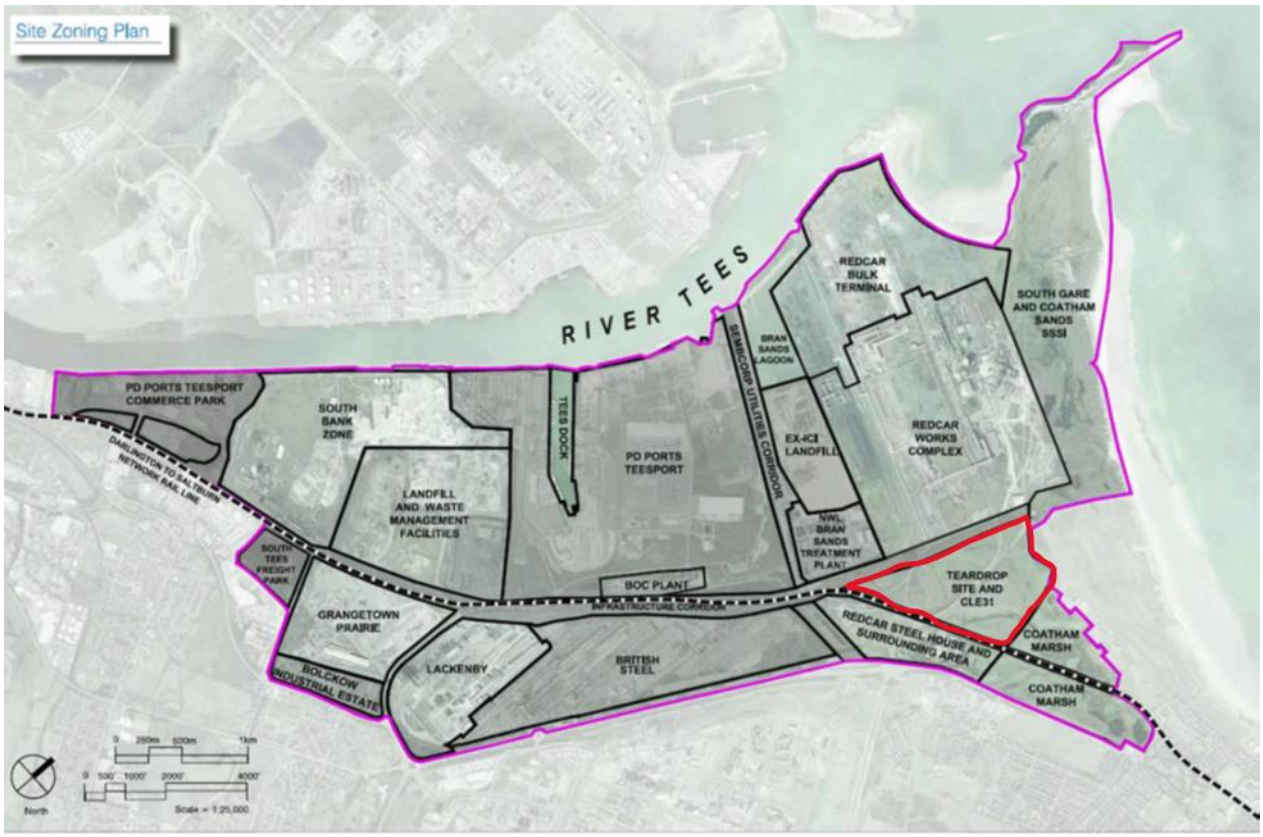

Figure 1. Complete Teesside PMSD site. The CLE31 zone, the area specified for site investigation, is shown in red.

Figure 2. Landfill and waste management areas, including the SLEMS.

The objective of the site investigation for Teesside was to undertake a detailed geophysical survey of one area within the site. Specifically, the area available was CLE31 (Figure 1).

1.2 INITIAL SITE VISITS

An initial site visit took place on the 21st July 2021. The purpose of this visit was to view the entire site and to discuss the REGENERATIS objectives with the South Tees Development Corporation. The following figure highlight the range of landscape observed at the site, with the buildings due to be demolished as part of the site redevelopment.

Figure 3. Images taken during the initial site visit (July 2021).

A further site visit was arranged on the 29th March 2022. The focus of this visit was to view the CLE31 zone, which was allocated to the REGENERATIS project for the site investigation work.

The area mostly comprised of deposited slag materials, though various pieces of scrap materials were also noted. Vegetation growth existed in some areas within the CLE31 zone. Whilst much of the zone was flat and accessible, there were some piles and evidence that the deposits were not fully secure, likely due to the layers of the slag and air pockets as a result (Figure 5). The CLE31 zone is shown in the following images.

Figure 4. CLE31 zone at the Teesside site.

Figure 5. Layers of slag within CLE31 zone.

2 SAMPLING PLAN

2.1 GEOPHYSICAL

Multi-method geophysical measurements at the Teesside CLE31 site. Two categories of measurements are scheduled: (i) magnetic and electromagnetic measurements to map variations in the metallurgical deposit, and (ii) 2D and 3D measurements to image vertical variations. The geophysical measurements will allow the estimation of the physical properties of the slag (electrical conductivity/resistivity, chargeability, magnetic susceptibility) which can be related to the geochemical properties of the steel deposits.

The longitudinal and lateral profiles are shown in Figure 6, the locations of which could be adapted during the survey. The aim of these profiles is to obtain an overview of the structure from the surface to the natural ground.

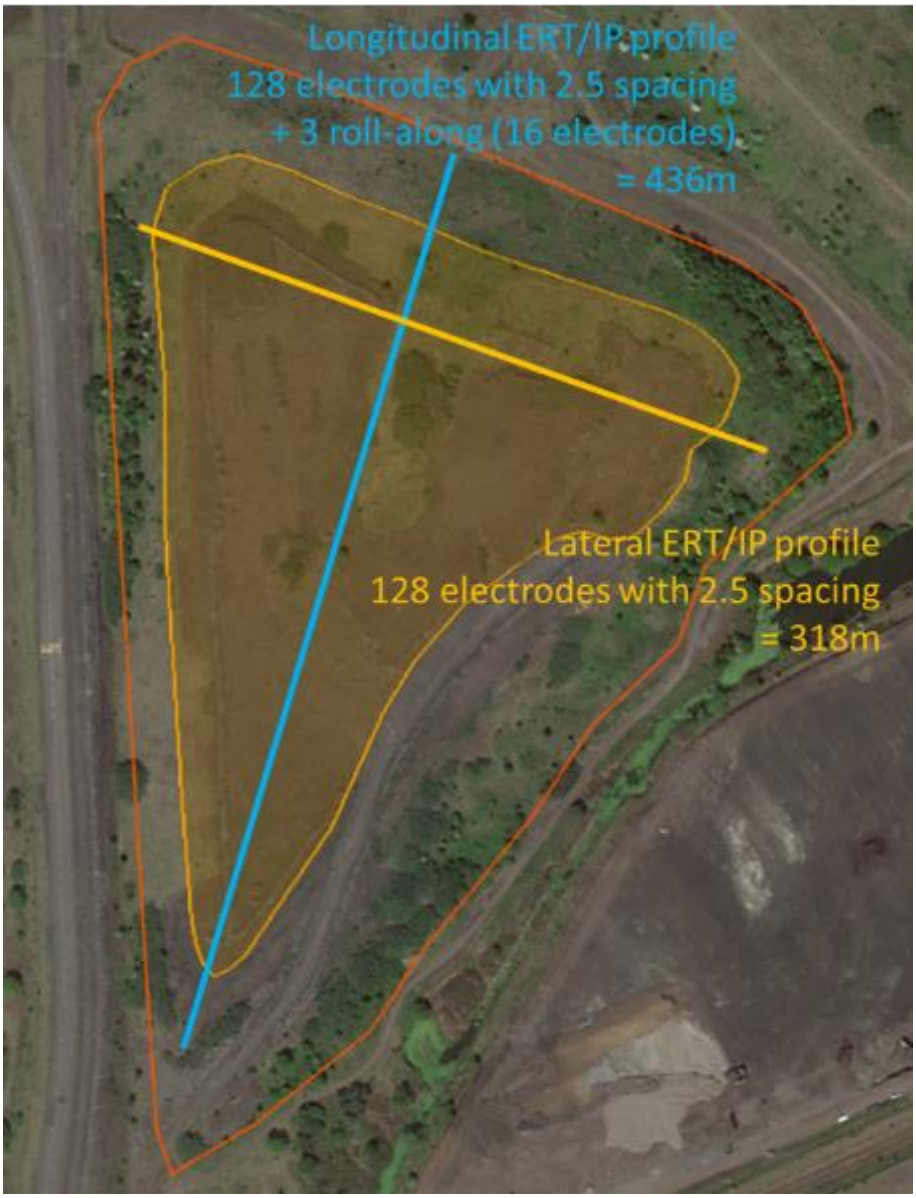

Figure 6. Longitudinal and lateral ERT/IP profile (Electrical Resistivity Tomography and Induced Polarisation).

Electrical Resistivity Tomography and Induced Polarisation setup is provided in Figure 7. In this example, first profile P1 and P2 will be measured simultaneously. Then, P1 is moved to P3 location to proceed the second measurement, and so on until P4/P5 profiles are measured. Their location would be defined according to EMI and Mag survey.

Figure 7. Example of 3D ERT/IP set-up (Electrical Resistivity Tomography and Induced Polarisation).

2.2 SAMPLE COLLECTION AND ANALYSIS

During the site survey, material will be extracted from the ground using hand augers and/or shovels. These samples will ideally be at depths to enable validation of the geophysical analysis results. Samples extracted will be taken to Cranfield University for detailed characterisation, including:

1. Metal content
    a. ICP-MS analysis for total metals
    b. XRF analysis to represent in-field measurements (handheld XRF cannot be taken to the Teesside site)
2. Basic characterisation (moisture, ash etc)
3. Bioleaching tests for metal mobilisation and recovery

4. Hydrometallurgical recovery using deep eutectic solvents and chelating agents

The results of the off-site analysis will enable validation of the geophysical analysis and also aid in the development of metal recovery process identification (WP T2).

3 SCHEDULE

16/05/2022

- BRGM, ULiege and CU team arrival at MPI offices.

17/05/2022

- Electromagnetic Induction mapping (EMI) using the DUALEM instrument. The instrument continuously emits an electromagnetic field and measures the response of the subsurface. The mapping consists of passing the instrument over the entire site while towing it on a trolley behind a vehicle - Magnetic mapping (Mag) using G858 and G856 Geometrics instrument, as well as Sensys FGM3D.

- A drone photogrammetry fly to obtain precise 3D elevation model of the CLE31 site.

18/05/2022

Morning- EMI and Mag survey will be completed.

Afternoon- lateral 2D ERT/IP profile commence at the northern part of the site (see Figure 7) with 96 electrodes with 2.5 m spacing. The acquisition is divided in 7 parts:

1. The line is set-up using decameters.
2. The stainless electrodes are sunk approximately 10 cm deep with a hammer following the defined spacing; 0.5L saline water or bentonite will be added at each electrode to improve the electrical ground contact, if necessary.
3. The cable is put in the ground and connected to the electrodes using clip-on connectors.
4. The cables are connected and with the main instrument at the center of the profile.
5. ERT and IP measurements are carried out in the same sequence. Two different sequences are made (reciprocal and normal one) in order to estimate measurements error. The measurement takes about 2 hour 30 minutes.

During ERT/IP measurements, Niton and Kappameters measurements completed. This dual measurement could be of interest for the interpretation of the geophysical results. In addition, metallurgical waste will be sampled using an auger or a shovel for off-site analysis.

19/05/2022

Using the same methodology, the longitudinal ERT/IP profiles will be acquired. In order to reach the length up to 472.5 m (i.e. 192 electrodes with 2.5 spacing). The regular resistivity-meter unit (96 electrodes) is extended with a 96-electrodes switch unit (Switch Terra 96 unit) along the profile in order to carry out the tomography in a single step. The total duration for the

acquisition with a 20-channel resistivity-meter (Syscal Terra) is estimated around 4 hour 30 minutes.

During ERT/IP measurements, Niton and Kappameters measurements completed. This dual measurement could be of interest for the interpretation of the geophysical results. In addition, metallurgical waste will be sampled using an auger or a shovel for off-site analysis.

20/05/2022

A 3D survey will be set-up. This part will be defined in function of the mapping results (EMI and Mag). The aim is to provide a precise 3D characterization over area of interest.

The 3D acquisition consists of the implementation of four 2D parallel ERT/IP lines (see Figure 7). The electrode spacing will be 2.5 m. The set of 192 electrodes is divided in two parts: each part is a sub-set composed of 2 lines (i.e. 96 electrodes) separated by 5m, and the spacing between sub-sets is 25 m After the first acquisition, the whole set is removed and is shifted 30m from the previous set. Using this grid pattern, it is possible to measure the resistivity contrasts along the lines and between the lines.

During ERT/IP measurements, Niton and Kappameters measurements completed. This dual measurement could be of interest for the interpretation of the geophysical results. In addition, metallurgical waste will be sampled using an auger or a shovel for off-site analysis.

21 and 23/05/2022

These two days will be focused on the finalization of the 3D set-up.

24/05/2022

The last day will be used to finalise the measurements made and to pack up the equipment for the return journey Wednesday 25th.